Single Particle Absorption Measurements in the Mid-Infrared by Exploiting Elastic Scattering

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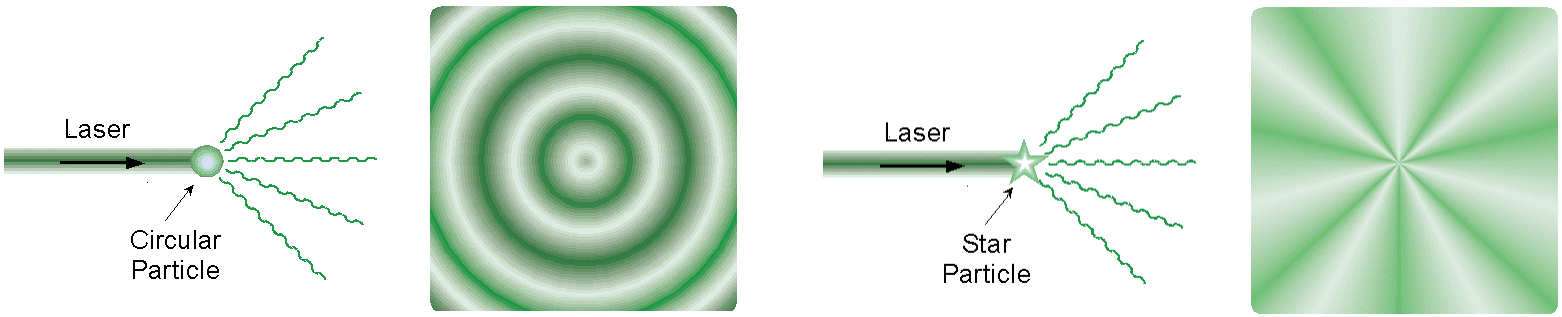
Goal: Measure the infrared absorption and scattering cross-sections for single biological and chemical aerosol particles.

Use: Single particle measurements are necessary for detailed modeling and understanding of test results from infrared stand-off detection systems.

Technique:

Two-dimensional Angular Optical Scattering (TAOS)

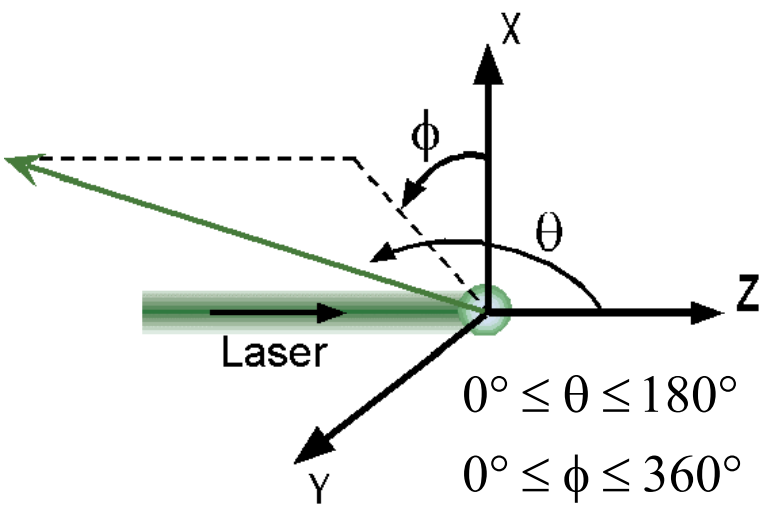


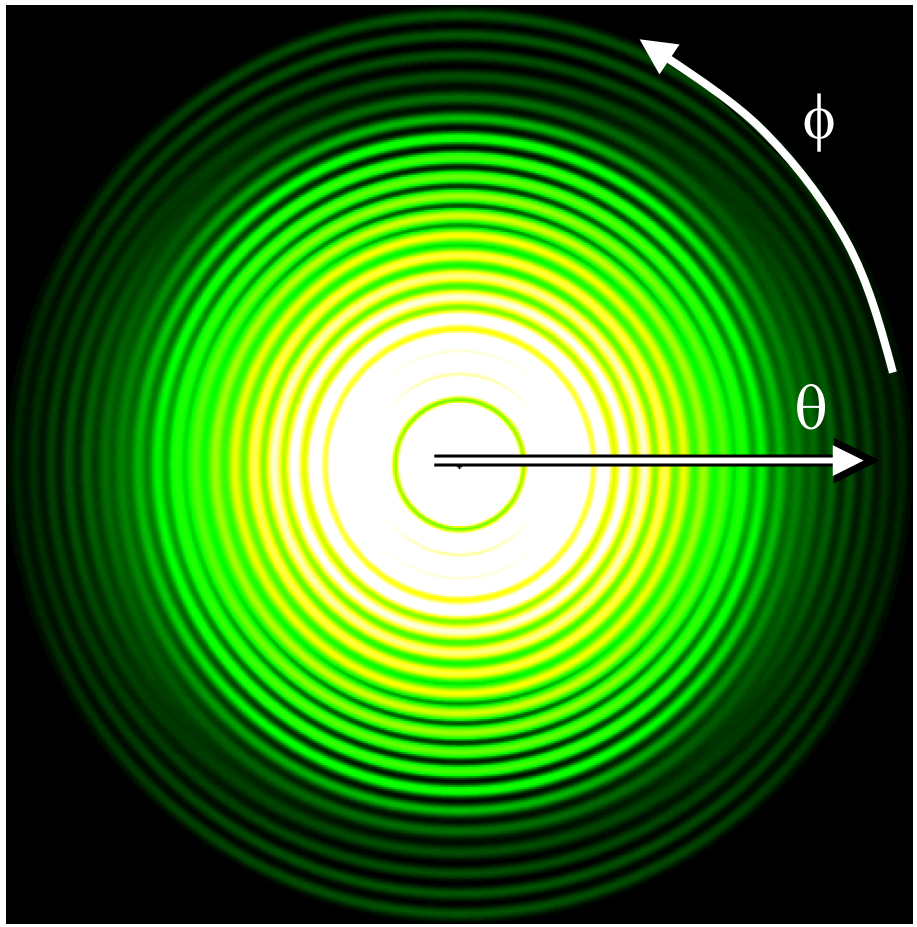
TAOS patterns depend upon particle shape, size, and **complex refractive index**

Coordinates for TAOS patterns

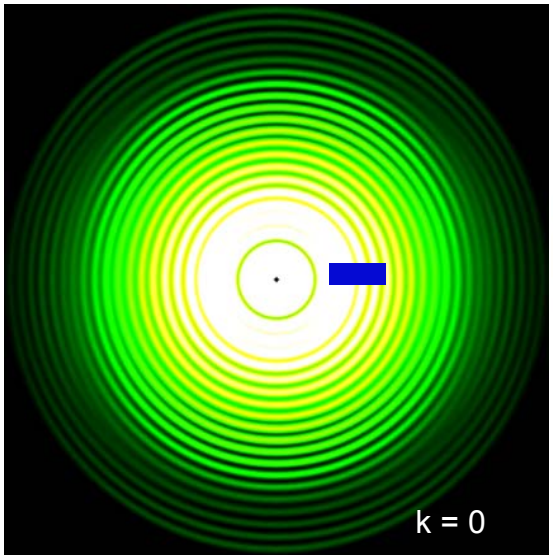
Scattering Parameters

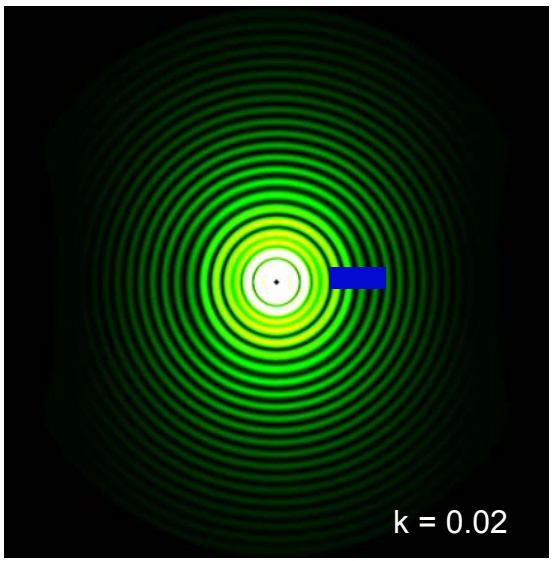
Diameter: 54.2 μm
Refractive Index: 1.342 + i * 0.00
Wavelength: 3.41 μm
Size Parameter: $2\pi^*a/\lambda \cong 50$
Laser Polarization: Vertical

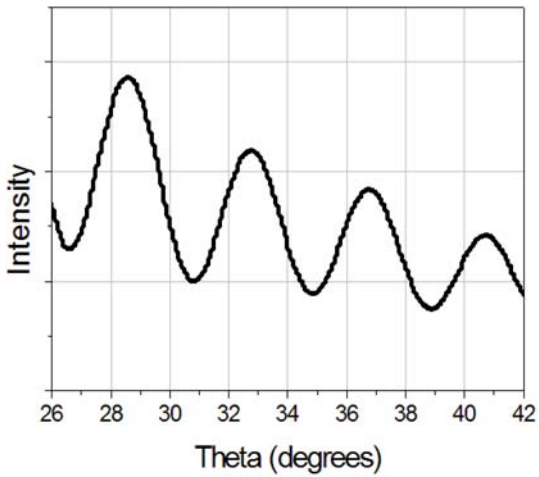


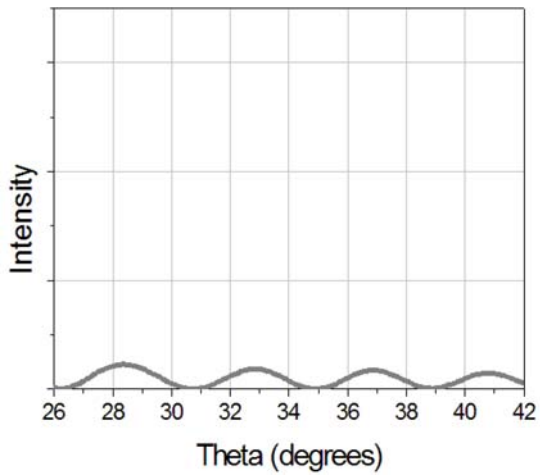


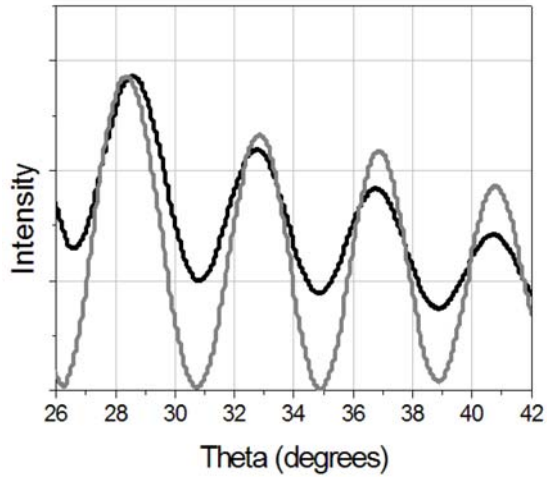
Extrapolate absorption cross-sections of spherical particles by comparison with Mie theory





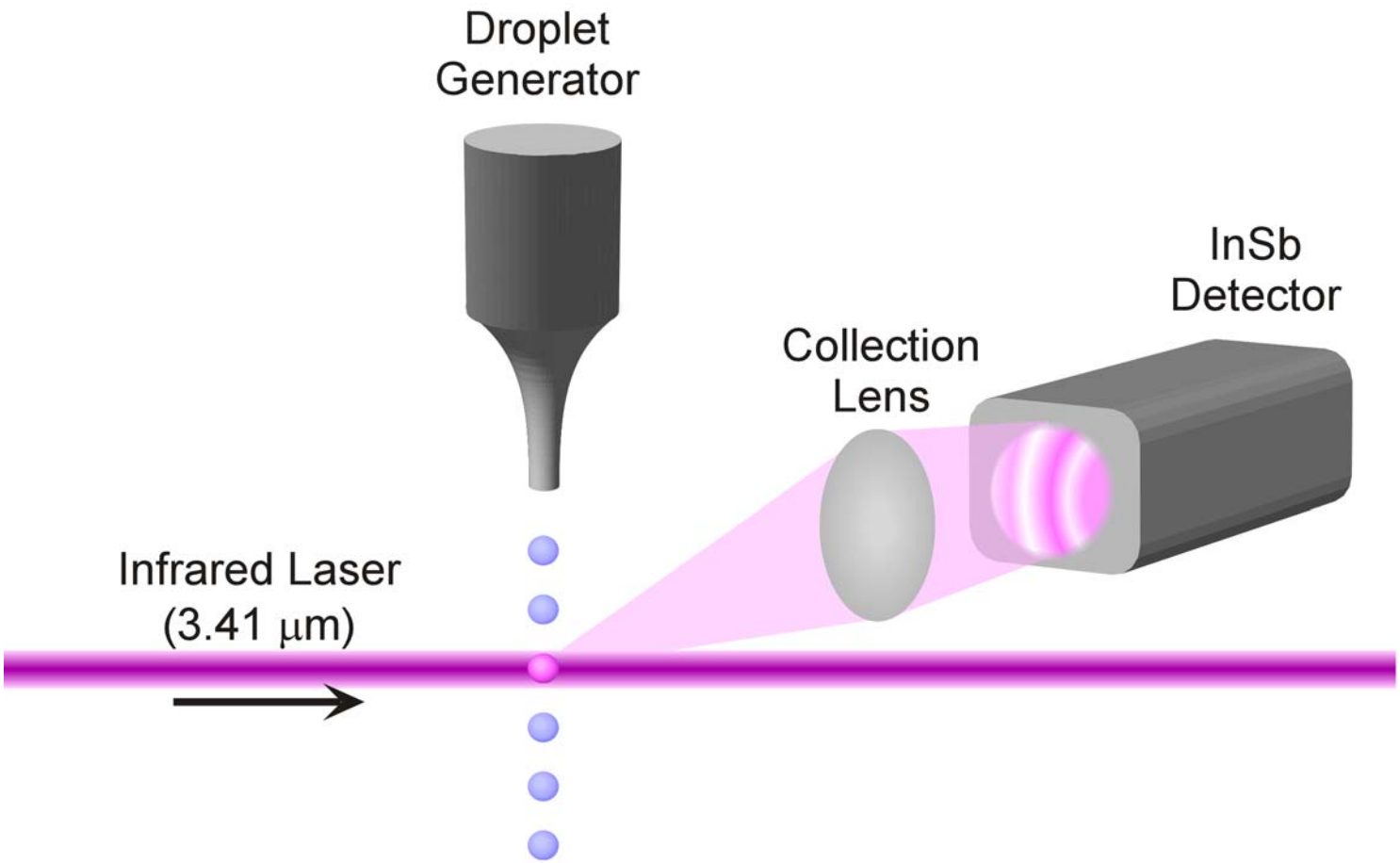






Changes in absorption leads to changes in the scattering profile beyond just a scale factor.

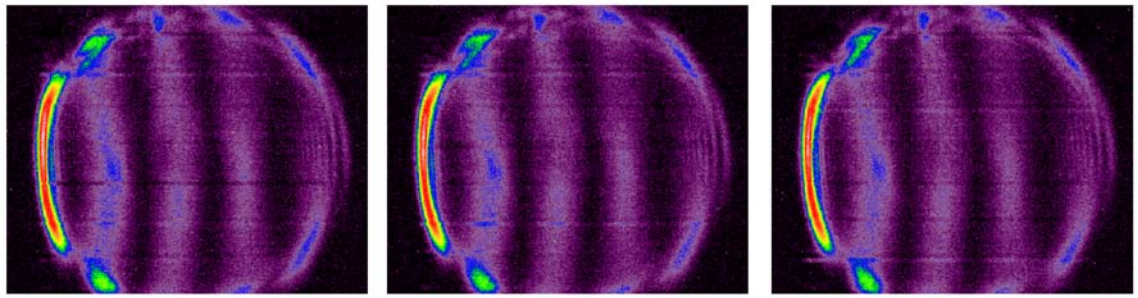
Experimental set-up to collect TAOS patterns of droplets



Collected TAOS patterns of droplets

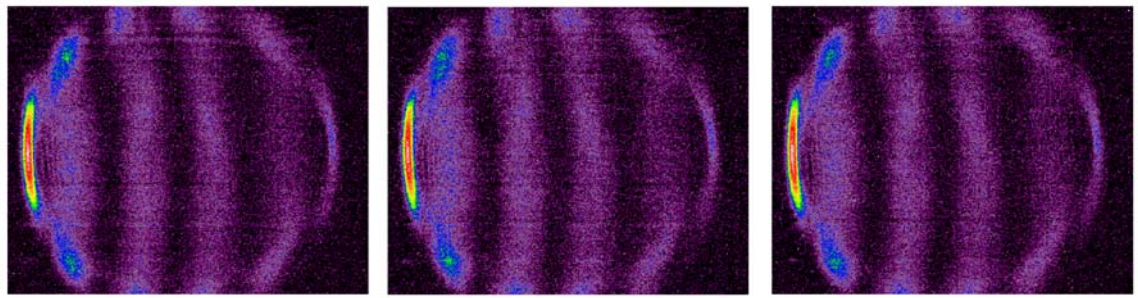
H_2O

Droplet Diameter: 57.4 μm
Refractive Index: 1.405 + i 0.018



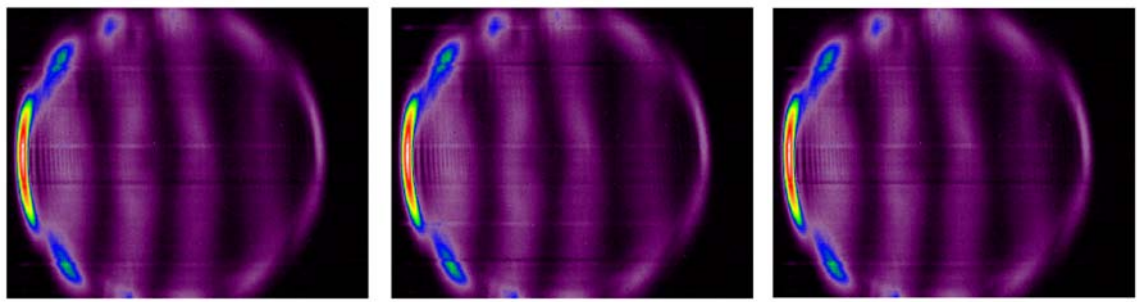
50% H_2O - 50% D_2O

Droplet Diameter: 54.2 μm
Refractive Index: 1.342 + i 0.010



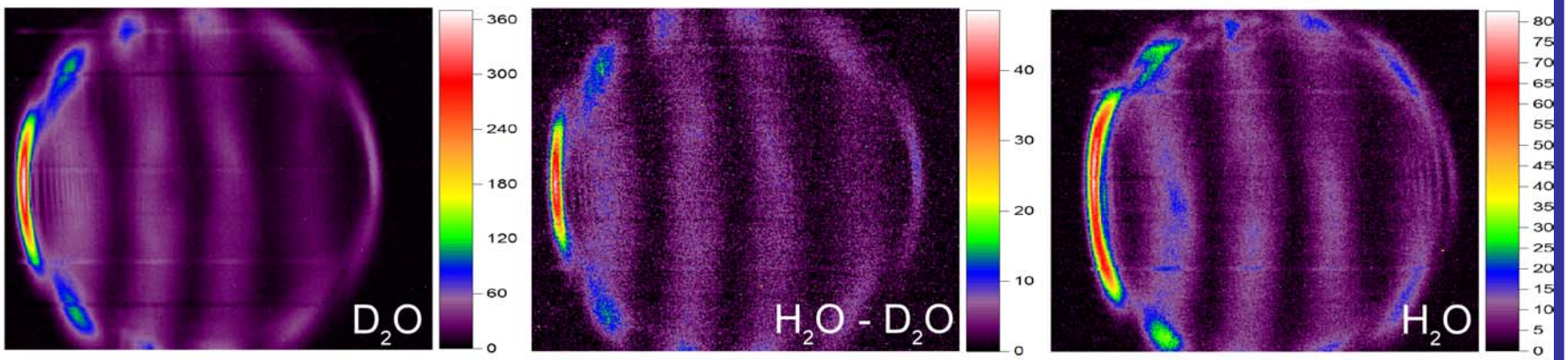
D_2O

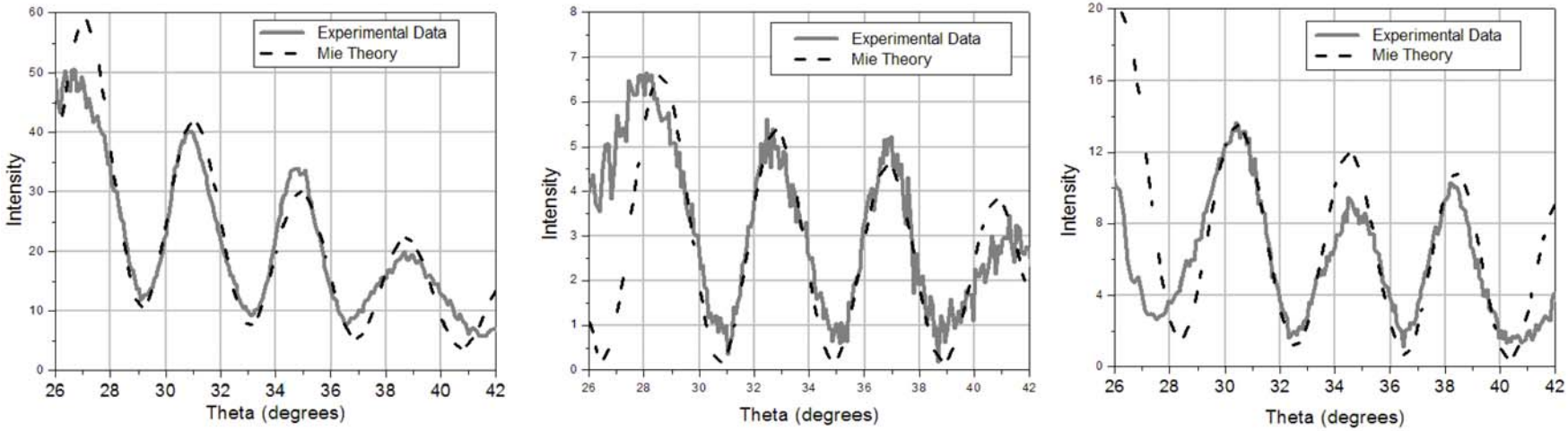
Droplet Diameter: 55.2 μm
Refractive Index: 1.279 + i 0.002



Comparison between experiment and Mie theory

D_2O	50% H_2O - 50% D_2O	H_2O
Droplet Diameter: 55.2 μm Refractive Index: 1.279 + i 0.002	Droplet Diameter: 54.2 μm Refractive Index: 1.342 + i 0.010	Droplet Diameter: 57.4 μm Refractive Index: 1.405 + i 0.018

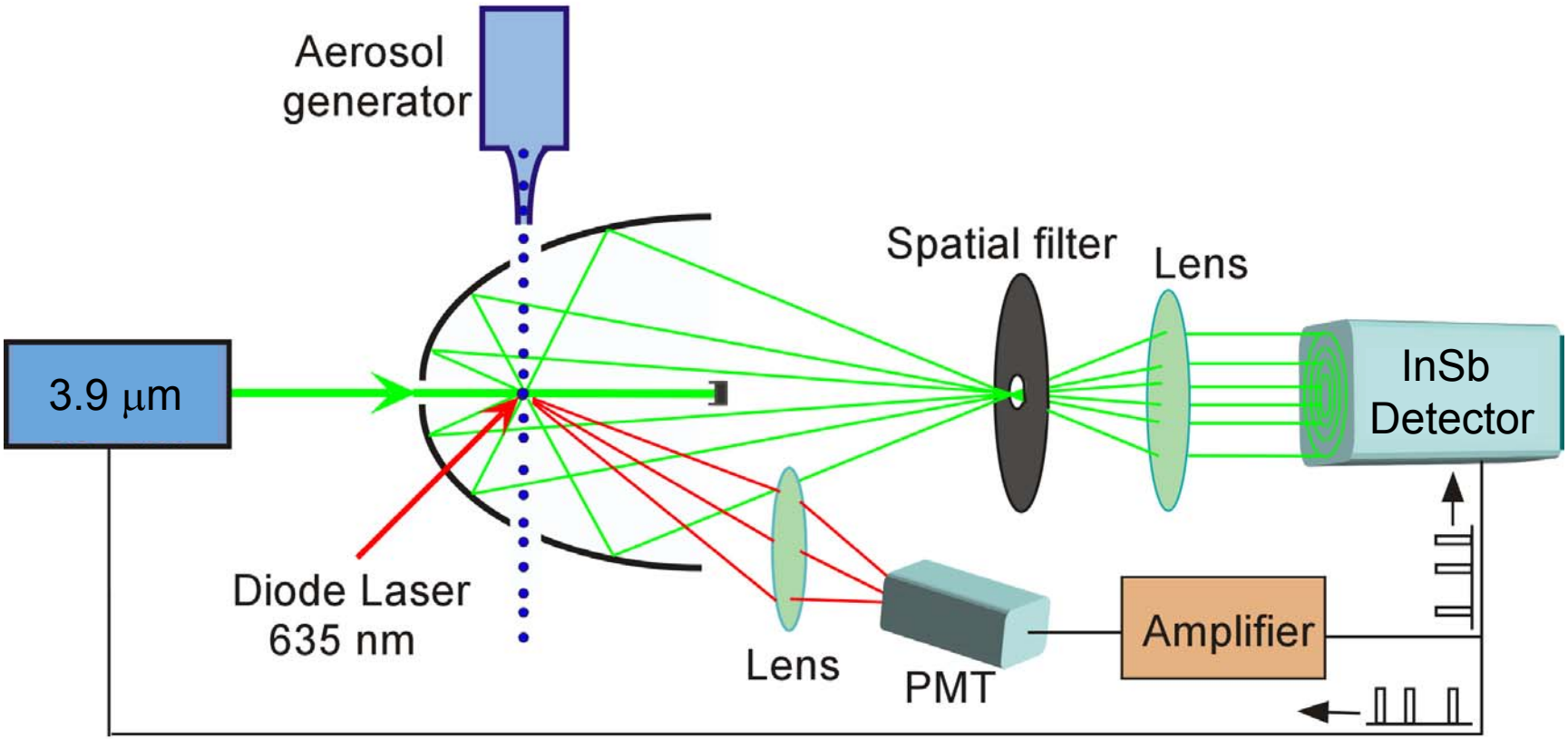




Current work

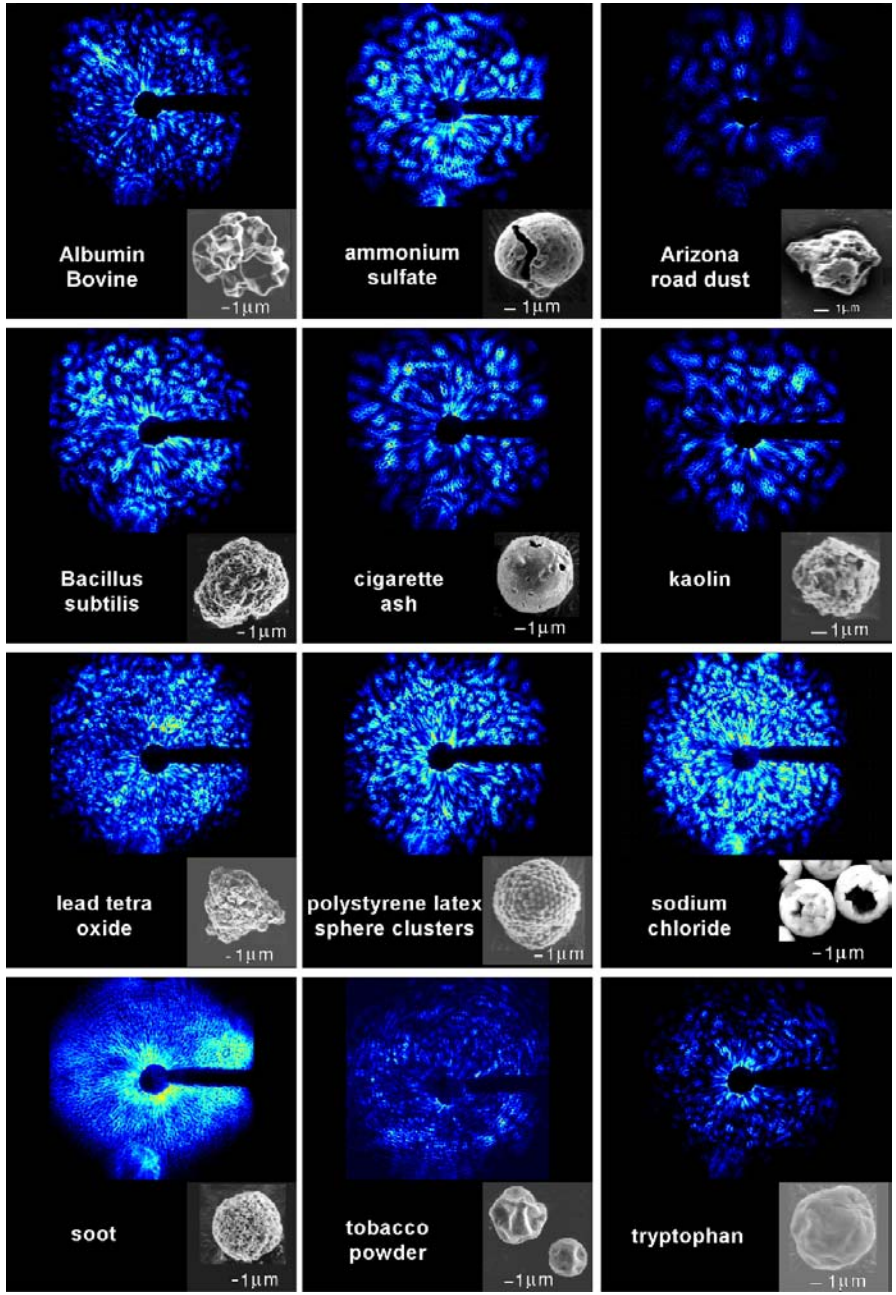
Collaboration with MIT Lincoln Lab

(Anish Goyal, Tom Jeys, and Antonio Sanchez)



Large Angle Two-dimensional Angular Optical Scattering

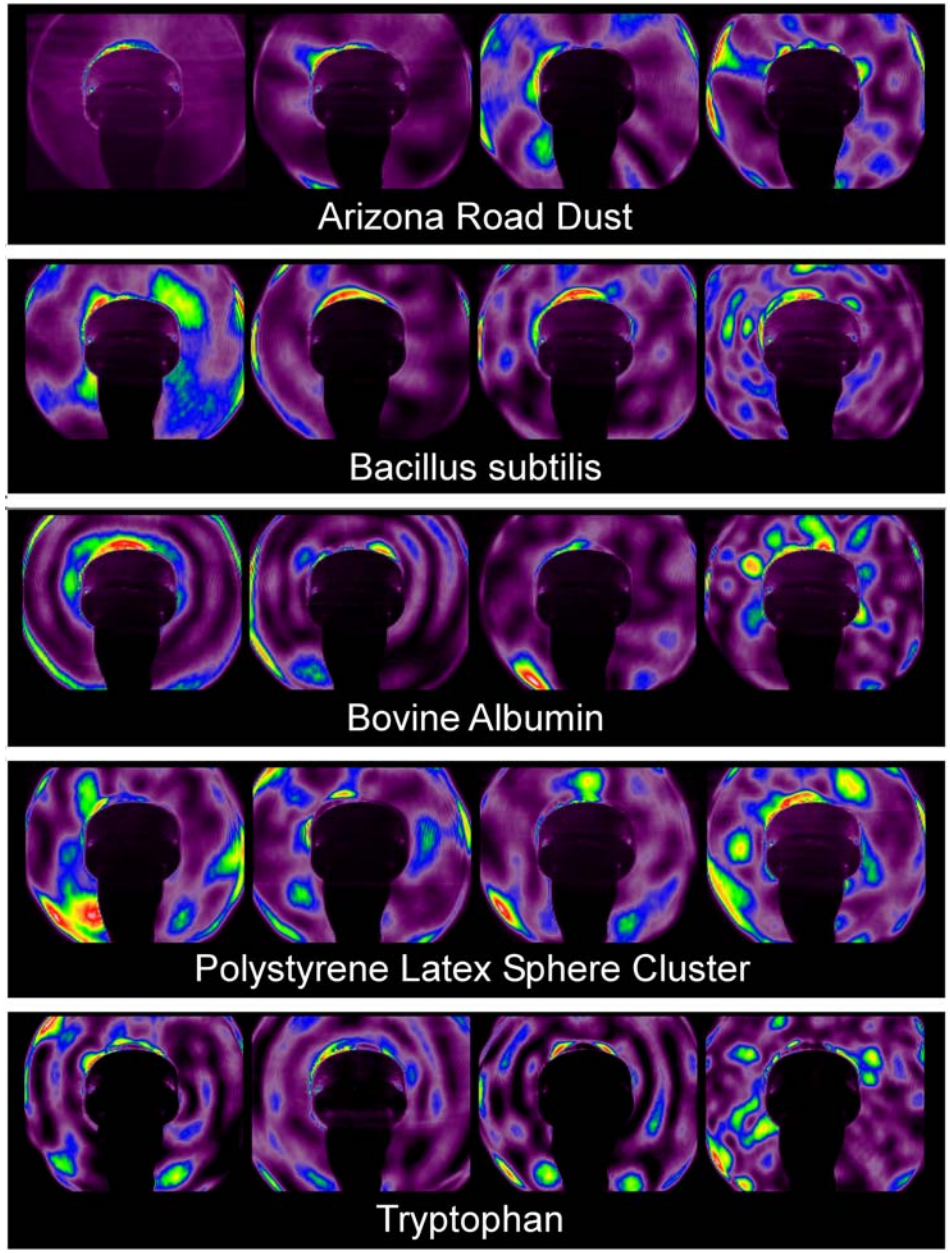
LA TAOS patterns collected in the **visible** of clusters ($\lambda = 532$ nm)



LA TAOS patterns collected in the **mid-IR** of clusters

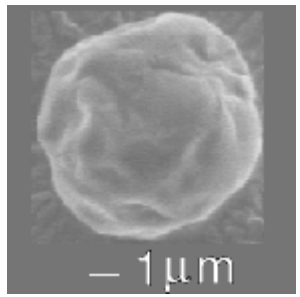
(λ = 3.9 μm)

Variability within a data set is due to multiple factors: cluster size, shape, and orientation, and optical alignment distortions.

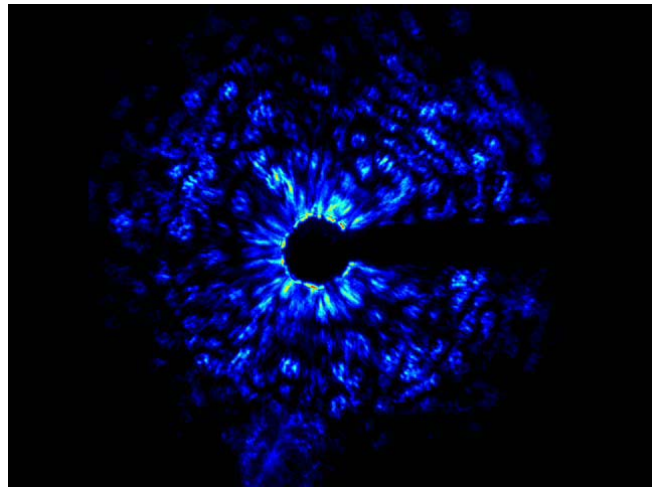


LA TAOS in the visible and mid-infrared

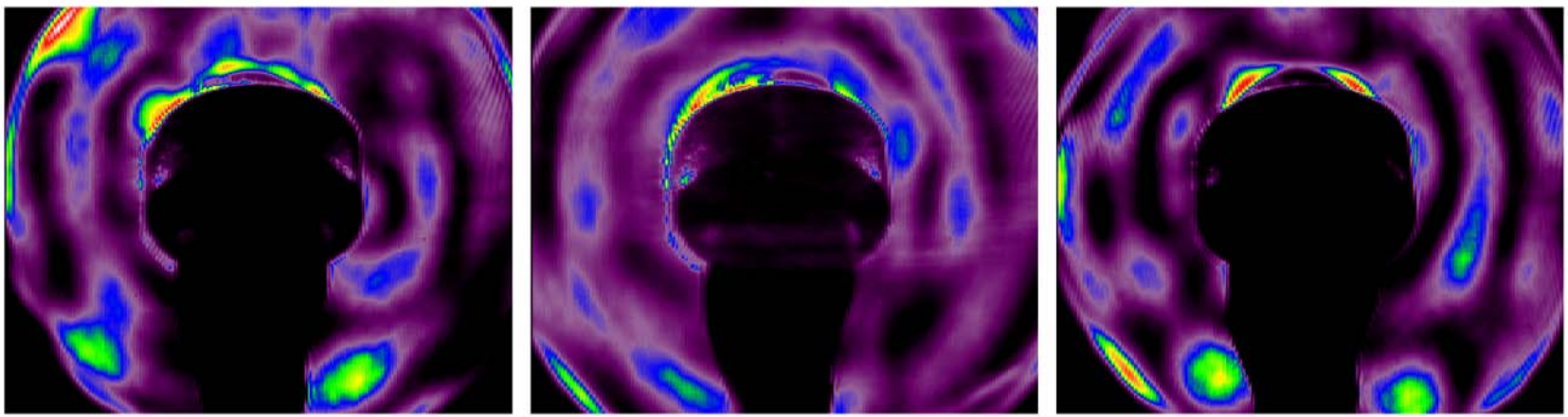
By increasing the wavelength, the LA TAOS technique becomes more sensitive to larger structure sizes.



SEM of Tryptophan

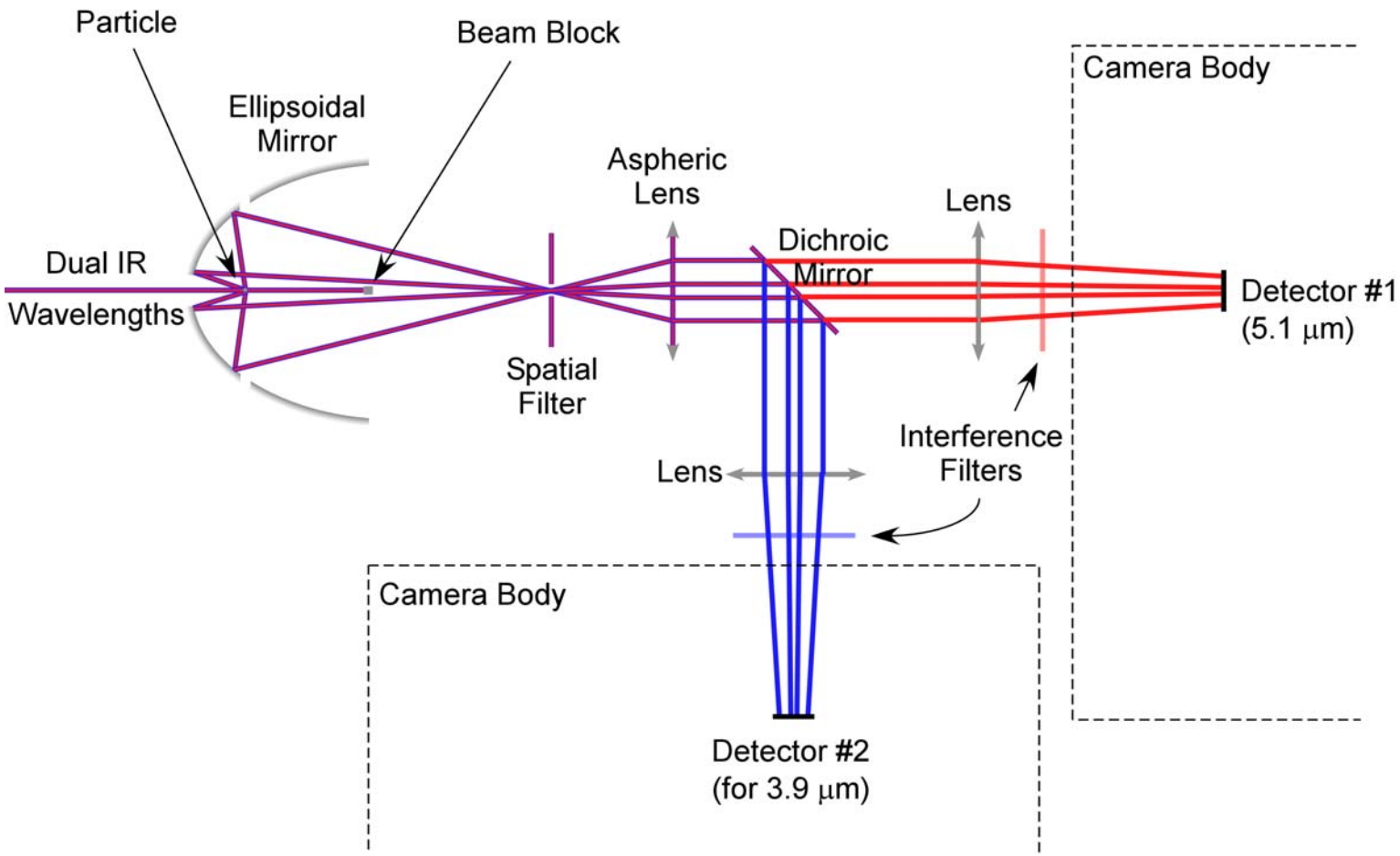


Visible LA TAOS pattern of Tryptophan at λ = 532 nm



Mid-IR LA TAOS patterns of Tryptophan at λ = 3.9 μm

Future Plans: Capture Dual Wavelength LA TAOS



Use two mid-infrared wavelengths to simultaneously illuminate an aerosol, then compare the LA TAOS patterns to ascertain if there is absorption at either wavelength.

Summary of Work

- Detected TAOS patterns of single 50 μm droplets composed of H_2O, D_2O, and H_2O/D_2O mixture.

- Able to achieve decent visible match with results derived from Mie theory.

- Unable to implement a minimization routine to find absorption because of aberration in the collection optics as well an inability to determine absolute angle reference.

- Collected LA TAOS patterns of Arizona Road Dust, BG, Bovine Albumin, PSL sphere cluster, and Tryptophan